

Claims

[c1] What is claimed is:

1. A method of medical imaging comprising the steps of:
zero-filling at least a first portion of k-space;
applying a fat suppression pulse to suppress signals
from fat in an ROI;
acquiring MR data from the ROI prior to full fat recovery;
and
filling at least a second portion of k-space from the MR
data.

[c2] 2. The method of claim 1 wherein the step of acquiring
MR data includes segmenting data acquisitions into a
number of imaging segments for each phase encoding
view, and acquiring multiple slice encoding lines per
imaging segment, and further comprising the steps of
repeating application of the fat suppression pulse for MR
data acquisition for each imaging segment.

[c3] 3. The method of claim 2 further comprising the step of
filling each phase encoding view of k-space with full-
fat-recovery-free MR data.

[c4] 4. The method of claim 3 wherein the step of filling in-

cludes sampling MR signals from the ROI with a segmented sequential encoding order having a k-space trajectory starting at or near a center of k-space to a periphery of k-space.

- [c5] 5. The method of claim 4 further comprising the step of determining a flip angle for the fat suppression pulse such that magnetization of fat within the ROI is at or near a null point at the filling of the center of k-space.
- [c6] 6. The method of claim 3 wherein the step of filling includes sampling MR signals from the ROI with a reverse segmented sequential encoding order having a k-space trajectory from a periphery of k-space to at or near a center of k-space.
- [c7] 7. The method of claim 6 further comprising the step of determining a flip angle for the fat suppression pulse such that magnetization of fat within the ROI is at or near a null point at the filling of the center of k-space.
- [c8] 8. The method of claim 1 wherein the step of zero-filling includes zero-filling in a slice direction.
- [c9] 9. The method of claim 1 wherein the fat suppression pulse includes a spectrally selective inversion recovery pulse.

- [c10] 10. The method of claim 1 wherein the step of acquiring MR data includes one of echo planar imaging (EPI), spoiled GRASS (SPGR) imaging, gradient echo (GRE) imaging, fast gradient echo (FGRE), fast imaging employing steady-state acquisition (FIELDA) imaging, time of flight (TOF) imaging, magnetic resonance angiography (MRA) imaging, fast spin echo (FSE) imaging, spin echo (SE) imaging, and stack spiral readout.
- [c11] 11. The method of claim 1 further comprising the step of reconstructing a uniformly fat-suppressed medical image from the MR data.
- [c12] 12. The method of claim 1 further comprising the step of acquiring the MR data during at least one of a breathhold and a non-breathhold moment.
- [c13] 13. The method of claim 1 further comprising the step of sequentially sampling the ROI and sequentially filling the non-zero filled portions of k-space.
- [c14] 14. The method of claim 1 further comprising the step of acquiring the MR data with a 3D fast gradient echo sequence (FGRE).
- [c15] 15. The method of claim 1 further comprising the step of defining a 3D volume of interest (VOI), and wherein the step of acquiring MR data includes the acquisition of 3D

data from the VOI.

- [c16] 16. The method of claim 1 wherein the step of acquiring MR data includes sampling MR signals from an excited region surrounding one of a liver or breast region of a medical patient.
- [c17] 17. The method of claim 1 further comprising the step of reconstructing a magnetic resonance angiography (MRA) image from the MR data.
- [c18] 18. A magnetic resonance imaging (MRI) apparatus to reconstruct MR images with substantially uniform fat suppression comprising:
 - an MRI system having a plurality of gradient coils positioned about the bore of a magnet to impress a polarizing magnet field and an RF transceiver system and an RF switch controlled by a pulse module to transmit RF signals to an RF coil assembly to acquire MR images; and
 - a computer programmed to:
 - define an ROI to be sampled for MR data acquisition;
 - select a slice direction;
 - zero fill at least a portion of k-space in the slice direction;
 - apply a fat suppression pulse to suppress signals from fat in the ROI;
 - acquire MR data from the ROI prior to full fat recovery;

and
repeatedly apply the fat suppression pulse and acquire
MR data to fill a remainder of k-space with less-
than-full-fat-recovery.

- [c19] 19. The MRI apparatus of claim 18 wherein the computer is further programmed to acquire the MR data during at least one of a breathhold and a non-breathhold moment.
- [c20] 20. The MRI apparatus of claim 18 wherein the computer is further programmed to sequentially fill the non-zero filled portions of k-space.
- [c21] 21. The MRI apparatus of claim 18 wherein the computer is further programmed to reconstruct a uniformly fat-suppressed medical image from the MR data.
- [c22] 22. The MRI apparatus of claim 18 wherein the fat suppression pulse includes a spectrally selective inversion recovery pulse.
- [c23] 23. A computer readable storage medium having a computer program stored thereon and representing a set of instructions that when executed by a computer causes the computer to:
 - define a slice direction;
 - zero fill less than an entirety of k-space in the slice direction;

apply a fat suppression pulse to suppress fat signals within an ROI;
acquire MR data from the ROI prior to full recovery of magnetization of fat within the ROI; and
repeat application of the fat suppression pulse and data acquisition to fill a remainder of the entirety of k-space with less-than-full-fat-recovery MR data.

- [c24] 24. The computer program of claim 23 wherein the computer is further caused to acquire MR data with one of segmented sequential encoding, reverse segmented sequential encoding, and centric encoding of k-space.
- [c25] 25. The computer program of claim 23 wherein the computer is further caused to automatically determine a flip angle of the fat suppression pulse such that fat is at or near its null point at the filling of a center of k-space.
- [c26] 26. The computer program of claim 25 wherein the flip angle is determined as at least a function of which encoding scheme is used to fill k-space.
- [c27] 27. The computer program of claim 26 wherein the flip angle is set to 100 degrees for segmented sequential encoding and set to more than 100 degrees for reverse sequential encoding.
- [c28] 28. An MR apparatus comprising:

means for exciting nuclei to precess at a given Lamour frequency when subjected to a substantially uniform magnetic field; and

means for fastly acquiring 3D MR data with uniform fat suppression during breathhold moments.